

PhD Course in Environmental Assessment Tools

Bridging Environmental and Economic Assessments for Decision Support

Experiences from an international Expert Seminar and PhD course in environmental assessment tools

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1 Background

The number of high-level courses available for PhD students and others with an interest in life cycle assessment (LCA) and other related environmental assessment tools is limited. Therefore, the LCA research team at Aalborg University, Denmark, decided to apply the Nordic Council of Ministers (Norforsk) for funding of a PhD course.

The course and the low participation fees were made possible by a substantial grant from Nordforsk and additional funding was received from the Doctoral School of Planning and Development, which is part of The International Doctoral School of Technology and Science at Aalborg University. The course was planned in cooperation with a group of Nordic researchers within this field from Norway, Sweden and Finland, also encompassing representatives from the 3R doctoral school (<http://www.3r.er.dtu.dk/>) and NorLCA (<http://www.norlca.org/CMS/site.asp?p=4485>) as well.

The course took place in September 15–21 2006 at Vraa Castle in Northern Jutland, Denmark, with 35 participants being mainly PhD students as well as a few experts from industry, consultancy firms and international organizations.

2 Bridging the Gap between Environmental Scientists and Economists

Environmental and economic assessments are important assessment tools for decision support in environmental management at both company and societal level. However, great differences can be observed in the methodological approaches. There are significant differences between different types of modelling (e.g. consequential versus attributional LCA), and between methods generally applied in LCA and cost-benefit analysis (CBA). There is only a best practice within CBA where no national or international standards are currently available. This is a problem, because different methods often give different results.

The main intention of the course was to contribute to a bridging of the gap between environmental scientists and economists, and to provide the basis for more consensus in the methodological approaches applied to promote sustainable production and consumption. Of special interest for the reader of this journal, the course focused on four important issues (development tendencies) within the methodology of LCA:

- From attributional towards consequential modeling in LCA
- Use and further development of environmental input output analysis (IOA or I/O-LCA)
- Integration of economic aspects in LCA – by combining LCA with CBA or LCC
- Integration of social aspects in LCA

The first item is mainly related to the goal and scope definition focusing on system delimitation or system boundaries. The second item is mainly related to the inventory phase of an LCA, while the two last are mostly related to phase three of a LCA, life cycle impact assessment.

3 Prominent Speakers

The course was based on the contributions from more than 20 presentations by some of the most recognized researchers within different fields covered during the course. The presenters included:

- Gregory A Norris (US)
- Bo Weidema (DK)
- Henrik Wenzel (DK)
- Karin Ibenholt (NO)
- Ole Jørgen Hanssen (NO)
- Christel Cederberg (SE)
- Edgar Hertwich (NO)
- Andreas Ciroth (D)
- Walter Klöpffer (D)
- Michael Hauschild (DK)
- Finn Arler (DK)

Gregory Norris and Bo Weidema made several presentations each and participated in the whole course. The main results and discussions of the course are described in the following according to the inherent logic of the course, starting with goal and scope, inventory and impact assessment phases of the assessment methodologies.

4 Consequential versus Attributional Modelling in LCA (related to goal and scope)

The course confirmed that great differences exist between the methodological approaches that prevail within different LCA research environments. What Gregory A. Norris referred to as the small Danish revolution 'consequential LCA' is far from being perceived as a common practice in countries others than Denmark, where it has become the officially recommended approach. As Henrik Wenzel from the Technical University of Denmark puts it; consequential modelling measures the difference in environmental impacts between two or more alternatives, e.g. one where a decision maker at a company or societal level chooses A instead of B. Here, Wenzel says, the assessment should include the 'induced' impacts as well as impacts that are 'avoided' as a result of the change. This is the essence of consequential modelling. In consequential modelling you cannot 'choose' your system, because it is constituted by the processes that change. At best, the LCA practitioner can identify it.

Consequential modelling is mainly characterized by applying system expansion to avoid co-product allocation, and by including affected (marginal) technologies/processes instead of average technologies as a default (when there are not specific ties to suppliers). If we take electricity consumption as an example, consequential LCA models the marginal source of electricity (gas or coal in the Nordic grid), while attributional LCA typically would suggest a mix of electricity sources, including wind turbines which do not produce according to marginal changes in demand.

The controversy between the two different ways of performing an LCA spurred a lively debate and, at the end of the day (literally speaking), most participants convened in using the idea, although there was still some scepticism. The main critique being raised against the consequential approach was that it:

- Can be difficult to understand and apply in some situations
- Is sensitive to the choice (or identification) of marginal technologies – identification of affected processes in relation to system expansion being a special case
- Is (or could potentially be) more open for misuse
- Could be problematic (at least in theory) because a large number of small decisions (marginal changes), on an aggregated level, reflect a larger decision and a 'large' change

It takes some time to become acquainted with the line of thought, but it simply boils down to one single principle; identify and include the processes which are most likely to be affected by the change that is being analyzed.

One further obstacle is that most databases currently reflect attributional modelling (e.g. ecoinvent). However, databases also exist which reflect a consequential approach for the main processes – examples are LCAfood, the Danish I/O database, and the upcoming I/O database for the EU. Furthermore, consequential modelling deals with the linking of processes – not the process itself.

It can also be argued that the high sensitivity of the method reflects the dynamics in the 'real' world being an opportunity to unveil hidden environmental problems and improvement potentials. It is thought possible that consequential modelling can be more easily misused, but at least it forces the practitioner to argue for a number of choices that would have remained hidden.

5 System Boundaries in LCA versus CBA (also related to goal and scope)

The results of LCAs can depend significantly on the assumptions behind the system delimitation. This generally well-established knowledge from environmental systems analysis was confirmed as one of the main conclusions of a review of existing LCAs of waste management of 7 material streams presented by Henrik Wenzel from the Technical University of Denmark. Wenzel and colleagues recently conducted the review for the UK Waste and Resources Action Programme (WRAP). In the review, 4 specific assumptions are considered to be essential to the outcome of a comparative study of waste management options for paper and cardboard. Among these is the assumption of the marginal electricity production technology in LCA. Marginal electricity production turned out to be a recurrent issue during the course. In general, a comparison of the system delimitation in LCA and CBA reveals that they differ in space and time. While the system delimitation in LCA can be global, depending on the product system(s) under study, the system delimitation in CBA is generally narrower following a national delimitation. Fur-

thermore, the use of discounting of future effects is standard in CBA, while it is only rarely done in LCAs.

6 I/O-LCA and its Application (related to inventory)

One of the most obvious weaknesses of conducting an LCA is the level of completeness. Process LCA assessing only a single product may have data gaps (missing data) representing up to 50% of the impact potential. The advantage of I/O-LCA (or top down LCA) is that it is based on an economic model that includes the entire economic system, including imports and exports. This means that the inventory is more complete and includes exchanges related to capital goods, services, investments, etc.

But I/O-LCA also has disadvantages. First of all, it is only possible to assess impacts from product groups such as 'clothing' (not a specific type of shirt or sneakers) and, secondly, it typically only includes fewer types of exchanges. There are different strengths and weaknesses related to process LCA and I/O-LCA (Table 1).

Still, the audience was somewhat puzzled about the practical application of I/O-LCA: What exactly should we use it for, when and how? A brain storm session at the seminar unveiled the following relevant application areas:

- Screenings to identify potential hot spots as a first step in a process LCA.
- Data source for data gaps in process LCA
- Verification of results from process LCA
- Identification of hidden exchanges (or impacts) in process LCA
- Studies of environmental impacts from product groups (where the level of detail is less important), e.g. prioritization of environmental policies at a society level
- As a basis for assessment of impacts from more specific product types, by disaggregating I/O-LCA product categories (embedded hybrid analysis)
- Modelling marginal spending in process LCA

Concerning marginal spending, one of the weaknesses of process LCA is that price differences practically never are accounted for. There are often considerable price differences between product alternatives. When price differences are not taken into account, the study neglects that money saved on buying product A instead of product B is spent on other products which also have an impact. This 'hidden' impact can easily be included in the assessments by multiplying the amount of money saved with the average environmental exchange per unit of value. These data are readily available in I/O-LCA databases. On a more sophisticated level, it is possible to model the spending pattern and make a more detailed assessment hereof.

During the seminar, the participants had the opportunity to get hands-on training with calculation software for doing I/O-LCA as Pré had supported the course with licenses.

Table 1: Typical strengths (+) and weaknesses (–) of different types of LCA, with inspiration from presentations and discussions at the seminar

	Process LCA	I/O LCA	Embedded hybrid
Analysis of specific product types	+	–	+
Completeness of inventory items	–	+	+
Included exchanges types	+	–	+
Uncertainty of exchanges	–	+	+

7 Integration of Economical Aspects in LCA (related to inventory and LCIA)

Economic aspects can be integrated in LCA in different ways. In his presentation on Total Cost Assessment (TCA), Gregory Norris outlined the TCA method as an accounting approach to non-conventional costs like environmental, health and safety costs that matches a company's conventional accounting conventions. In TCA, Life Cycle Costing (LCC), scenario analysis and LCA are integrated according to Norris. Based on the experiences of a TCA project for multi-national companies, Norris described how the TCA method has been applied as decision support with estimated benefits of hundreds of millions of dollars. However, it must also be acknowledged that different interpretations of TCA exist. According to Norris, Total Cost Assessment is not the same as Total Cost Accounting that is narrower in scope. The upcoming work from the UNEP working group on LCC, will hopefully serve to clarify the concepts.

Andreas Ciroth, from GreenDeltaTC and a member of the SETAC-Europe Working Group on Life Cycle Costing, outlined in his presentation the history of conventional LCC and the development of two new types of LCC: environmental and societal LCC. According to Ciroth, the environmental LCC is complementary to an environmental LCA, while societal LCC can be considered to be complementary to a CBA with its consideration of externalities. An ISO standard for conventional LCC in certain industries is being drafted (ISO 15663), while, for environmental LCCs, the framework and principles of the well-known ISO standards for conducting LCA studies (ISO 14040 and 14044) is used and broadened to also include costs.

8 Integration of Social Aspects (mainly related to LCIA)

Integration of social aspects in environmental assessment was another topic addressed during the course. Social impacts represent an increasingly important parameter for company decisions – partly because issues such as child labour have caught the interest of the media. Gregory Norris also stressed that assessments which neglect the social element, may lead to decisions that represent sub-optimization or burden shifting.

Weidema proposed a method for quantification of social impacts based on 14 inventory items (missing education, corruption, missing property rights, etc.). The items were selected among key indicators for social pressure described in the social impact assessment literature, e.g. the Global Reporting Initiative. On the endpoint level, it was suggested that it is relevant to use the QALY indicator (Quality Adjusted Life Years), which captures social impacts on three levels: The mortality gap, the health gap and the well being gap. The mortality gap says something about the frequency of people who die at different ages, the health gap tells something about non-fatal impacts on human health in terms of frequency, duration and severity of disability (covering deceases and injuries), while the well being gap measures the social impacts related to other aspects of well-being (here, frequency, duration and severity are accounted for as well).

Greg Norris pointed out that social impact can be measured at the endpoint 'human health' which is used in traditional

LCA's – we just have to add a socioeconomic pathway. Norris argues that traditional LCA only cover risk factors representing around 3% of the total share of the global burden of disease (measured in DALY). Norris argues that product policies which do not address the remaining 97% of the global burden of disease – risk representing a shift of burden problem.

Small increases in per capital GNP in developing countries contribute (on average) to significant increases in mean life expectancy in those countries. This suggests that products, which to a high degree stimulate economical activity in developing countries, often (not always) have an advantage in terms of positive social impacts (expressed in mean life expectancy) – even though the same products may represent a bad alternative in terms of eco-efficiency. However, it must be recognized that many variables are involved such as the level of corruption, distribution of income, public investments in education, hospitals, etc.

9 Communication, Coaching and Follow-up

The course featured a unique opportunity to involve the expert presenters of the course as supervisors and coaches during a three-month follow-up period focused on article writing. This provided an opportunity for the PhD students to gain extra 5 ECTS additional to the 5 ECTS gained by ordinary participation. 5 articles were submitted to international journals within the deadline set by the course organizers to earn the full 10 ECTS. Still, the participants valued this aspect as extremely relevant and something to be recommended to other organizers.

The course homepage (<http://enveco.plan.aau.dk/>) served as an efficient platform for both internal and external communication. No additional printed marketing was used at all. To assure sufficient time for search engines to familiarize, the site was launched 10 months before the course. Within the first year, 62 external websites linked to the course homepage causing very attractive scores by relevant Google searches. Together, these two net-based marketing channels provided visitors, which soon reserved the 35 available seats. For the participants, the intranet held summaries, slides, literature databases and reference texts as well as other practical information. The user statistics showed that more than a thousand unique users created more than 30,000 hits from 77 countries (not counting search engines, etc.). Almost 700 of these unique visitors bookmarked the site (83% of the hits). Therefore, most visitors returned several times and 300 have spent more than 30 minutes on the site.

Walter Kloeppfer, Editor-in-Chief of Int J LCA, gave a lecture on 'Publishing Scientific Articles with Special Reference to LCA and Related Topics'. He found the greatest interest and response reflected by vivid discussions.

The course was successful and accomplished its mission; Bridging the gaps. It really took place in an inspiring atmosphere, creating professional bonds for life among a larger group of PhD students – the next generation of LCA and CBA practitioners. Hopefully, we will be able to launch such an event again. The homepage, of course, will be open for all participants and other interested researchers with information of new courses, articles and so on, at least for the remaining part of 2007.